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Origin of Intermittency in Economic and Solar-Terrestrial Systems

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Abstract

Characterization of the complex dynamics of economic cycles, by identifying regular and irregular patterns and regime switching between different dynamic phases in the economic time series, is the key to improve economic forecasting. Statistical analysis of stock markets and foreign exchange markets have demonstrated the intermittent nature of nonlinear economic time series, which exhibits non-Gaussian behavior in the probability distribution function of price changes and power-law dependence on frequency in the spectral density. Nonlinear deterministic models of economic dynamics are capable of simulating intermittent time series due to a transition from order to chaos, or from weak chaos to strong chaos, which can explain the origin and nature of intermittency observed in economic systems.

We discuss the complex systems approach to intermittency based on a forced van der Pol oscillator of business cycles and a model of Alfvén chaos in the solar-terrestrial environment. The technique of numerical modeling is applied to characterize the fundamental properties of complex economic and solar-terrestrial systems which

exhibit multiscale and multistability behaviors, as well as coexistence of order and chaos. In particular, we focus on the dynamics and structure of unstable periodic orbits and chaotic saddles within a periodic window of the bifurcation diagram, at the onset of a saddle-node bifurcation and at the onset of a crisis, as well as in the chaotic regions associated with type-I intermittency and crisis-induced intermittency. Inside a periodic window, chaotic saddles are responsible for the transient motion preceding convergence to a periodic or a chaotic attractor. The links between chaotic saddles, crisis and intermittency in complex systems are discussed. We show that a chaotic attractor is composed of chaotic saddles and unstable periodic orbits located in the gap regions of chaotic saddles. Both type-I intermittency and crisis-induced intermittency are the results of the occurrence of explosion at the onset of bifurcation, whereby the gap regions of chaotic saddles are filled by new unstable periodic orbits are created by the explosion.

Nonlinear modeling of chaotic saddle, crisis and intermittency can improve our understanding of the dynamics of economic and financial intermittency observed in business cycles and financial markets, as well as the dynamics of climate change and space weather. In view of the universal mathematical nature of chaotic systems, the results obtained from our simple prototype model of economic dynamics can in fact be applied to more complicated economic scenarios, including spatiotemporal economic systems. Characterization of the complex dynamics of economic systems provides an efficient guide for pattern recognition and forecasting of business and financial cycles, as well as for optimization of management strategy and decision technology.

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